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NOVEMBER 1990
HARRISBURG STEAM GENERATION FACILITY
HARRISBURG, PENNSYLVANIA

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I. SUMMARY

In June 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the City of Harrisburg to conduct a health hazard evaluation at the City's Steam Generation Facility. This facility incinerates municipal refuse to generate electricity. The request concerned potential exposures to fly ash, combustion products, and asbestos.

On July 11-12, 1989, an initial "walkthrough" site visit was made. On October 24-26, 1989, a follow-up visit was made for the purpose of conducting environmental monitoring for total and respirable particulates, trace metals, crystalline silica, and asbestos. Bulk samples of ash, insulation, and settled dust were collected. Surface wipe samples were obtained to assess potential surface contamination with metals.

The environmental data obtained by NIOSH investigators indicates the potential for high total particulate exposures (fly ash) for employees working in the boiler and basement areas, including the boiler fireman and laborers. Total particulate exposures ranging from 5 to 11 milligrams per cubic meter (mg/m^3) were obtained on the laborers. Although the personal breathing zone (PBZ) air concentrations of aluminum, cadmium, chromium, iron, and nickel were below existing guidelines and standards established by NIOSH and OSHA, the concentration of lead in three of the PBZ air samples exceeded the OSHA PEL of 0.05 mg/m^3 as an 8-hour time-weighted average (TWA) or 0.03 mg/m^3 as a 12-hour TWA. Air samples obtained on the boiler fireman and two laborers indicated airborne concentrations of 0.09, 0.09, and 0.14 mg/m^3, respectively. NIOSH recommends that lead exposures be kept below 0.10 mg/m^3. Crystalline silica was not detected in any of the PBZ air samples analyzed.

Amosite and chrysotile asbestos were identified in bulk samples of insulation and chrysotile asbestos was present in a settled dust sample obtained in the boiler area. The poor condition of some of the insulation coverings and the presence of asbestos in settled dust samples, as well as in loose insulation samples obtained from the floor, indicates the potential for inhalation of asbestos fibers and the need for further evaluation and abatement.
Surface wipe samples indicate a potential for hand-mouth contact with fly ash, particularly from surfaces in the break and locker room.

The environmental data obtained at HSGF indicate a need for reducing worker exposures to fly ash particulates, as lead overexposures and high total particulate concentrations were measured for the boiler fireman and laborers. Recommendations for reducing particulate exposures through the use of engineering and work practice controls are made in the Recommendations Section of this report. Recommendations are also made to increase cleaning and maintenance activities, and to further evaluate asbestos contamination at this facility.

KEYWORDS: SIC 4953 (Refuse systems), 4931 (Electric and other services combined) municipal refuse, incineration, waste-to-energy, fly ash, lead, metals, asbestos.

II. INTRODUCTION

In June, 1989, NIOSH received a request from the City of Harrisburg to conduct a health hazard evaluation (HHE) at the Harrisburg Steam Generation Facility (HSGF). The HHE request concerned potential exposures to fly ash, combustion products, and asbestos. An initial survey was conducted on July 11-12, 1989, and a follow-up survey on October 24-26, 1989. On the initial survey, bulk insulation and fly ash samples were collected, and direct reading measurements were made for carbon monoxide and oxides of nitrogen (combustion products), temperature and relative humidity. A letter which summarized the results and observations from the initial survey and included preliminary recommendations was sent to HSGF representatives on July 24, 1989. Exposure monitoring for total and respirable particulates, crystalline silica, asbestos, trace metals, and hexavalent chromium was performed on the follow-up survey.

III. BACKGROUND

Harrisburg Steam Generation Facility is a waste-to-energy plant located in Harrisburg, Pennsylvania. Municipal refuse from Harrisburg and neighboring areas is incinerated at approximately 1400°F, and the steam which is generated is either sold directly, or converted to electricity via an on-site turbine. The plant consists of two 360-ton capacity boilers which are approximately 20 years old. A diagram of the incinerator is shown in Figure 1.

The plant has storage capacity for two days, and operates 24 hours a day, seven days per week. The operating crew includes approximately 50 people. Employees work either conventional 8-hour shifts or 12-hour shifts. Jobs include equipment operators who are responsible for loading the refuse into the charging hopper and loading ash onto a dump truck; laborers, who perform general clean-up of the basement area and remove large metal objects from the combined ash; maintenance mechanics, who repair equipment as necessary, often working away from the boiler area; operation mechanics, who perform daily preventive maintenance, spending a portion of their day in the boiler and basement areas; boiler firemen, who are responsible for checking the fire and grate systems as well as the overall operation of the boilers; utility men, who fill in as needed; a control room operator who is responsible for the boiler controls; and a shift supervisor.

Personal protective equipment used by employees includes hard hats, safety shoes and glasses, work clothes, and single-use (disposable) dust and mist respirators. Respiratory protection is not always worn by employees, however. Although showers are available for employees, their use is not enforced.

The plant has four wall exhaust ventilation units; however, they were not in operation at the time of this survey. Open windows and open louvres in the roof comprised the ventilation for the boiler and basement areas.

IV. EVALUATION DESIGN AND METHODS

Sampling and analytical methods used in the evaluation of worker exposures and specific workplace contaminants are presented in summary form in Table I.

All air sampling trains were calibrated prior to the commencement of sampling, and air flowrate and sample integrity were checked periodically during the workshift. Personal exposure monitoring was conducted over the entire workshift. Personal breathing zone air samples were analyzed for total and respirable particulates, crystalline silica, asbestos, hexavalent chromium, and trace metals.

Exposure monitoring was conducted primarily on employees in jobs which were expected to have the greatest potential exposures to the contaminants listed above, such as the boiler firemen and laborers. Additionally, personal breathing zone air samples were collected on maintenance mechanics and welders who spend less time in the boiler and basement areas. Their exposures are generally more variable, as work activities on any given day are dependent on the particular operating conditions of the boiler on that day. Exposure monitoring was also conducted on the truck driver, who is responsible for loading ash onto a dump truck and disposing of it on the ash pile located on the HSGF property.

Short-term area air sampling for combustion products including carbon monoxide and oxides of nitrogen was conducted in the basement and boiler areas using the Draeger gas detection system. Surface wipe samples for trace metals were obtained on several high skin contact areas, including the break and locker room, and the boiler control room. Surface wipe samples were also obtained in the the turbine control room, for comparison. Bulk samples of ash, settled dust, and insulation were collected for analysis of asbestos, trace metals, and crystalline silica. In addition, temperature and relative humidity measurements were made at several locations within the plant.

V. EVALUATION CRITERIA

A. General

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week, for a working lifetime without experiencing adversehealth effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the level set by the evaluation criterion. These combined effects are not often considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) Permissible Exposure Limits (PELs). The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Substance Specific Evaluation Criteria and Health Effects Summary

A list of the contaminants evaluated in this survey is presented in Table II, along with a brief summary of primary health effects. For trace metals, only those elements which have the greatest toxicological significance are included in the Table.

VI. RESULTS

Results of the industrial hygiene evaluation are presented in the following sequence: bulk samples; personal and area air sampling datafor silica, asbestos, total and respirable particulates, trace metals, hexavalent chromium, and combustion products; and surface wipe sampling data for trace metals.

A. Bulk Samples

Results from the analysis of seven ash samples (including both fly ash and combined ash) are shown in Table III. The following metals and minerals were present in concentrations greater than one percent: aluminum, calcium, iron, magnesium, sodium, titanium, and zinc. Some potentially toxic elements were present in lesser amounts, including cadmium, cobalt, chromium, copper, nickel, and lead. Although there is a wide range in the concentrations of individual elements in these samples, the relative elemental distribution shows little variation between samples. Variations in elemental concentrations of the ash are expected, due to the nature and inherent variability of the refuse materials received.

Four bulk ash samples were analyzed for the presence of crystalline silica (quartz and cristobalite). No cristobalite was present in any of the bulk samples to a limit of detection of 0.75%. One sample had no detectable quartz (less than 0.75%), two samples hadconcentrations between the limit of detection and the limit of quantitation (0.75% to 1.5%), and one sample had a concentration of 1.5% quartz.

Table IV lists the results of the bulk insulation and settled dust analyses for asbestos. Chrysotile asbestos was present in concentrations exceeding 1% by volume in three of the 11 samples collected at this facility. Two of these samples were pipe insulation samples which contained 30-40% asbestos, and one was a settled dust sample collected on the outboard side of the unit #1 long screw which contained 5-10% chrysotile asbestos. Amosite asbestos was found in two bulk samples. One sample contained 80-90% amosite and was taken from the outer covering of insulation for the main steam line on the roof. A sample of loose insulation taken from the floor of the boiler level contained 70-80% amosite.

B. Air Samples

Of the six air samples analyzed for respirable crystalline silica, none contained any detectable levels of quartz or cristobalite, to a limit of detection of 0.015 milligrams (mg) per sample(< 0.02 mg/m^3). Three of the air samples were obtained on laborers, one was obtained on a welder and the remaining two air samples were general area samples collected in the basement.

Personal breathing zone (PBZ) and general area air samples for asbestos were obtained on the boiler fireman and in the area near the unit #2 feed-water line. Despite the use of short-term consecutive air samples, the particulate loading on these filters was heavy; therefore, an accurate fiber count was not possible. These air samples were subsequently analyzed by polarized light microscopy and, in some cases, also by transmission electron microscopy. Amosite asbestos, glass fibers and cellulose were present in the PBZ and area air samples described above. Only cellulose fibers were present in the outdoor air sample obtained outside the turbine control room.

Air sampling data for total and respirable particulates are shown in Table V. PBZ air concentrations of total particulates ranged from 1.2 to 11.5 mg/m^3. The highest concentrations of total particulates were obtained on the three laborers, at 5.1, 5.3, and 11.5 mg/m^3. This is not unexpected, as these workers spend most of their time in the basement area where particulate levels are highest, and where job activities require clean-up of the area. Respirable dust concentrations ranged from 0.3 to 0.7 mg/m^3. The air samples analyzed for total and respirable particulates were obtained to assess overall particulate burden. These concentrations cannot be compared with the nuisance dust evaluation criteria, as specific toxic elements are present in the ash.

Air sampling data for the following trace metals are shown in Table V: aluminum, cadmium, chromium, copper, iron, nickel, and lead. Although other elements and minerals were present in these samples such as calcium, magnesium, manganese, sodium, titanium, and zinc, the table includes only those elements of greatest toxicological significance. Although not included in the table, the concentration of calcium, which was present in the highest concentration in these air samples (as well as in the bulk ash samples) ranged from 0.05 to 3.8 mg/m^3. Again, the airborne concentration of the various elements listed in the table were higher for the laborers and boiler firemen, as compared with the mechanics, welders, and custodial staff who spend less time in the boiler and basement areas. As shown in the Table, PBZ exposures to aluminum, cadmium, chromium, copper, iron, and nickel were well below their respective evaluation criteria. Of the 15 PBZ air samples analyzed, three exceeded the the OSHA PEL for lead which is currently set at 0.05 mg/m^3 as an 8-hour TWA and 0.03 mg/m^3 as a 12-hour TWA. These air samples were obtained on the boiler fireman and two laborers, at 0.09, 0.09, and 0.14 mg/m^3, respectively. NIOSH recommends that lead exposures be kept below 0.10 mg/m^3 as a 10-hour TWA.

Area air samples obtained near the Unit #1 long screw and Unit #2 discharge were analyzed for the presence of soluble and insoluble hexavalent chromium (Cr(VI)). No soluble Cr(VI) was detected in either sample to a limit of detection of 0.001 mg/m^3. Insoluble Cr(VI) was present in low concentrations in both samples, at 0.001 mg/m^3. NIOSH recommends that exposures to both soluble and insoluble Cr(VI) be reduced to the lowest feasible level as NIOSH considers all Cr(VI) forms as potential carcinogens.

Carbon monoxide was not detected in the grab air samples obtained on July 12, 1989, with the exception of one sample obtained on the 4th floor catwalk which gave a concentration of approximately 5 ppm CO. The current OSHA PEL for CO is 50 ppm and the NIOSH REL is 35 ppm, both as 8-hour TWAs. Oxides of nitrogen were not detected in two grab air samples obtained on the 1st and 4th floors of the boiler; the limit of detection was 0.5 ppm. It should be noted, however, that grab air samples were not obtained on the follow-up survey, at which time the level of smoke in the environment appeared to be significantly greater.

Air temperatures measured on the initial survey ranged from 83NF in the basement area to 115NF on the 5th floor catwalk. Relative humidity ranged from 50% in the basement to a low of 18% on the 5th floor catwalk. Although workers generally do not spend much time on the upper levels of the boiler, the data indicates the potential for heat stress, should maintenance or other activities be performed which require workers to remain in the area for significant periods of time.

C. Surface Wipe Samples

Six surface wipe samples and four unopened wipes (Wash N' Dri towelettes) were analyzed for the presence of trace metals and minerals. Because the unused towelettes contained aluminum, calcium, iron, magnesium, sodium, zinc, and trace amounts of copper, the average blank value for these towelettes was subtracted from the field samples. Little variation in elemental concentration was found in the blank towelettes. Results from the surface wipe sampling are shown in Table VI. Although not shown in the table, calcium was present in the highest concentrations in the field samples, with concentrations ranging from 56 to 763 micrograms per square foot (ug/ft^2). In general, the distribution of the various elements listed in the table from higher to lower concentrations is as follows: iron/aluminum > copper/zinc > titanium > lead > manganese > nickel > chromium/cadmium. Of the six locations evaluated, the bench in the break and locker room and the table in the boiler control room had the greatest surface contamination with the elements listed above. Although the boiler control room is located away from the plant in a separate air-conditioned area, workers from the incinerator area were observed in this area throughout the day.

VII. Discussion and Conclusions

The environmental data obtained on the follow-up survey indicates the potential for high total particulate exposures as evidenced by PBZ air concentrations of 5.1, 5.3, and 11.5 mg/m^3, which were obtained on the laborers. Not unexpectedly, the laborers and boiler firemen had the highest particulate exposures, due to their frequent handling of ash during general operation and clean-up activities, and the length of time spent in the boiler and basement areas (virtually all of their 8 or 12-hour workshifts). Although the respirable particulate exposures were fairly low ($\leq$0.7 mg/m^3) indicating that the airborne dust may be fairly coarse, this does not reduce the level of concern for the more toxic contaminants present in the ash, such as lead.

The personal exposure monitoring data presented in Table V demonstrates that worker overexposures to lead are occurring. A full-shift PBZ air concentration of 0.14 mg/m^3 was obtained on a laborer working a 12-hour workshift. This concentration is well above the OSHA PEL for lead of 0.03 mg/m^3 as a 12-hour TWA, and is also above the NIOSH REL for lead (<0.10 mg/m^3). The boiler fireman and another laborer also had lead exposures exceeding the OSHA PEL on the day of the survey. Measurable lead concentrations were obtained on all PBZ air samples with the exception of the air sample obtained on the truck driver, indicating that potentially significant lead exposures can occur for other workers who generally spend much less time near the incinerator, such as the mechanics and control room operator. These workers may have greater or lesser exposures on any given day depending on their assigned task and the nature of refuse material being incinerated.

Poor housekeeping practices, mechanical malfunctions, lack of engineering controls, and deficient personal hygiene facilities and practices all contribute to the workers' exposures discussed above. Based on observations made during these surveys, several potential sources of particulate exposure were identified, including: general cleaning of ash and debris in the pit and basement areas using shovels and brooms; removing accumulated ash and debris from the feed table when the boiler is not operating; cleaning out the "sifting run" by automatically discharging the residue onto the basement floor; removing the long screw covers; and blockages in the system which disrupts the air pressure differential causing contaminants to escape into the general room air. Surfaces contaminated with ash such as in the break and locker room, and boiler control room, provide an additional source of metal exposure, as shown in Table VI. Contact with contaminated surfaces as well as smoking, eating, or drinking in contaminated areas can result in hand-mouth contamination, which for metals such as lead, can result in toxicologically significant quantities being ingested. Poor housekeeping practices such as dry sweeping instead of using vacuums or wet methods, and improper use of the single use disposable respirators (straps not fastened, presence of beards) also contribute to particulate exposures.

There were several locations where asbestos-containing insulation was in poor condition, capable of releasing fibers into the air upon contact. In one area, a chunk of loose insulation was present which contained 70 to 80% amosite asbestos, and in another location a settled dust sample was collected which contained approximately 5 to 10% chrysotile asbestos. This, and the fact that asbestos fibers were identified on a PBZ air sample obtained on the boiler fireman, indicate the potential for inhalation of asbestos fibers, particularly in the boiler area. An accurate quantitative fiber count was not possible on the PBZ air samples, however, as a result of heavy particulate loading on these air samples.

Air temperatures up to 115°F were measured in the boiler area. Excessive heat stress during maintenance activities in hot areas of the plant presents a potentially serious health hazard during both cool and hot seasons, but especially during warmer weather. The limited temperature and humidity measurements made during this survey indicate the need for further evaluation of environment heat through the use of Wet Bulb Globe Temperature measurements which incorporate radiant heat and airflow measurements in addition to dry and wet bulb air temperatures.

VIII. RECOMMENDATIONS

Recommendations are made below to help minimize exposures to fly ash and asbestos. Although the HSGF employees are not covered under federal OSHA, recommendations are made below to comply with the OSHA lead standard, as this standard includes comprehensive information on engineering controls, work practices, use of personal protective equipment, medical surveillance, environmental monitoring and training. Recommendations regarding the prevention of heat stress also are included.

1. Particulate exposures should be reduced through the use of engineering controls. Some of the more important sources of particulate emissions that were observed include the long screw conveyor which transports fly ash from the electrostatic precipitator to the discharge bin, the residue discharger which receives the combined ash, and the pit area which is below the area where the ash is transported for removal. In addition, the practice of cleaning the feed table also resulted in the heavy release of particulates into the breathing zone of the boiler fireman and laborer who were responsible for this job. A system designed in such a way to minimize the release of ash and smoke into the plant while allowing for routine maintenance and dislodging of ash accumulated in the feed table is needed.

   Workers should not be allowed to clean out the "sifting run" as this practice releases ash and debris onto the basement floor. This activity was performed during the October 1989 survey without giving advance warning to the laborers who were working in the immediate vicinity. The area became so dusty that it was not possible to see across the room for several minutes. Aside from increasing the overall particulate levels, this practice could potentially have caused a serious accident if someone was standing below the discharge area at that time. If this practice must be continued, engineering controls should be provided to capture contaminants generated in the process. An engineer familiar with industrial ventilation systems should be contacted for assistance in designing appropriate engineering controls for reducing ambient particulate levels.

2. Worker exposures to lead should be reduced through the use of engineering controls (discussed above) and work practices. The requirements outlined in the OSHA lead standard (29 CFR 1910.1025)[1] should be followed. This standard includes provisions for periodic exposure monitoring, implementation of engineering and work practice controls where overexposures to lead occur, use of respiratory protection while engineering controls are being implemented or when controls are not sufficient to reduce employee

exposure to or below the OSHA PEL, provision of clean, protective clothing and lunchroom facilities, establishment of a medical surveillance program, and employee notification, education and training. As indicated in the standard, the use of single-use or disposable dust and mist respirators is not appropriate for workers who are or may be exposed to lead at concentrations exceeding the PEL. The use of half-mask, air-purifying respirators with high efficiency filters is required for these individuals. These respirators should be worn by the laborers and the boiler fireman until such time as personal exposure monitoring data indicate that worker exposures are below the PEL, as outlined in the standard.

3. A respiratory protection program consistent with the guidelines found in DHHS (NIOSH) Publication No. 87-116, "A NIOSH Guide to Industrial Respiratory Protection," and the requirements of the General Industry Occupational Safety and Health Standards (29 CFR 1910.134) should be implemented. Copies of these publications were previously provided.

4. Work practices including those listed below, which minimize worker exposure to ash and other contaminants should be encouraged.

   a. Smoking, eating, or drinking, should not be allowed in the incinerator area. These activities should be restricted to designated areas away from sources of contaminants. In addition, handwashing facilities should be located in the plant area and workers should be encouraged to wash their hands before eating, drinking or smoking. Workers should also be encouraged to shower at the end of their shift and to change into street clothes (leaving work clothes at HSGF) before leaving work.

   b. General cleaning, maintenance and preventive maintenance activities, should be increased. This includes activities such as removing piles of fly ash which accumulate in the basement area, periodically inspecting the long screw covers to ensure they are seated properly, repairing damaged pipes and conveyors to prevent ash release and hot water and hydraulic fluid leaks in the basement, use of a central vacuum system to cleanup ash and debris in place of dry or wet methods, prohibiting the use of compressed air for cleaning work areas or clothing, and periodic cleaning of tables, lockers, and other surfaces in the break and locker room.

5. A drop screen should be placed beneath the conveyor to catch loose debris and metal objects which fall off the conveyor so that workers cleaning out the pit are not injured by falling debris. A drainage system should also be added in this area to collect and remove the water which accumulates on the floor.

6. Management indicated that the services of a consultant were engaged to further identify sources of asbestos-containing materials within the plant and the extent of workplace contamination. If not already done, this work should be performed as soon as possible so that areas which require abatement can be identified and appropriate actions taken to minimize exposures to asbestos.

7. A formal heat stress program should be implemented. This program should include periodic measurements of environmental heat using Wet Bulb Globe Temperature (WBGT) measurements, employee training and education in appropriate ways to handle heat stress, first aid for heat illness, and preventive measures. Guidelines included in the NIOSH Criteria Document "Occupational Exposure to Hot Environments" should be followed. A copy of this document was previously provided.

8. A pre-placement physical should be offered to new employees with consideration given to the job or work areas to which the worker will be assigned. Conditions which can be encountered at this facility are high dust levels, toxic metals, asbestos, use of respiratory

protection, hot work environments and heavy manual labor. Consultation with an occupational physician is recommended to determine the appropriate tests and exams which should be performed and the frequency and need for periodic medical surveillance.

9. The services of a qualified industrial hygienist or other health and safety professional should be obtained to conduct periodic industrial hygiene evaluations at this facility. To assess the effectiveness of control measures, exposure monitoring should be conducted whenever work practice changes are made or engineering controls are implemented.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Harrisburg Steam Generation Facility
2. AFSCME Local 521
3. Pennsylvania Department of Labor and Industries

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table I

Sampling and Analytical Methods

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

July and October, 1989

Analyte or Agent	Sample Type[a]	Flowrate (Lpm)[b]	LOD & (LOQ)[c]	Analysis and Modifications
Asbestos	Bulk	NA	NA	The percentage of fibrous asbestos was estimated by a microscopic examination of the sample by two separate analysts. Results were averaged and reported in percent by volume. Polarized light microscopy and dispersion staining techniques were used.
	PBZ & GA	1-2.5	NA	NIOSH Method 7402 revision #1.[2] Asbestos presence and type was confirmed using transmission electron microscopy at 10500X magnification. Samples were collected on 25mm CEM filters using a conductive cowl.
Crystalline Silica (quartz and cristobalite)	Bulk	NA	0.75% (1.5%)	NIOSH Method 7500[2] (X-ray diffraction). Modifications: Filters were dissolved in tetrahydrofuran and samples and standards were run concurrently using an external calibration curve prepared from integrated intensities.
	PBZ & GA	1.7	0.015 mg (0.03 mg)	NIOSH Method 7500[2] with modifications listed above. Samples were collected on 37 mm pre-weighed PVC filters preceeded by a 10 mm cyclone (same sample was weighed for respirable dust).
Total Particulates	PBZ & GA	1-2	0.01 mg	NIOSH Method 0500[2] (gravimetric analysis). Samples were collected on pre-weighed 37mm PVC filters which were reweighed after sampling.
Respirable Particulates	PBZ & GA	1.7	0.01 mg	NIOSH Method 0600[2] (gravimetric analysis). Samples were collected on pre-weighed 37mm PVC filters preceeded by a 10 mm cyclone. Filters were reweighed after sampling.
Trace Metals & Minerals	Bulk	NA	1-50 ug/g	NIOSH Method 7300[2] (inductively coupled plasma emission spectroscopy). Thirty elements were analyzed simultaneously.

-Continued-

Table I (Continued)

Sampling and Analytical Methods

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

July and October, 1989

Analyte or Agent	Sample Type[a]	Flowrate (Lpm)[b]	LOD & (LOQ)[c]	Analysis and Modifications
Trace Metals & Minerals	PBZ & GA	1-2	1-20 ug/g	NIOSH Method 7300[2] (inductively coupled plasma emission spectroscopy (see preceeding description).
	Surface wipes	NA	(1.0 ug)	Pre-moistened towelettes (Wash N' Dri Brand) were used to wipe measured surface areas in a variety of locations. The towelettes were ashed in nitric & perchloric acids. The residues were dissolved in a dilute solution of the same acids and analyzed by inductively coupled plasma emission spectroscopy.
Chromium, Hexavalent:				NIOSH Method 7600[2] (visible spectroscopy). Samples were collected on 37mm 5.0-um PVC filters. Acidic or alkaline extraction solutions were used depending on the form of hexavalent chromium analyzed.
Soluble	PBZ & GA	1.5	0.2 ug (0.61 ug)	
Insoluble	PBZ & GA	1.5	0.1 ug (0.27 ug)	
Temperature and Relative Humidity	GA	NA	NA	A battery-operated psychrometer was used to obtain these measurements.
Carbon Monoxide	GA	NA	5 ppm	Direct-reading measurements were made for carbon monoxide and nitrogen oxides using the Drager gas detection system.
& Nitrogen oxides	GA	NA	0.5 ppm	

[a] PBZ = personal breathing zone air sample; GA = general area air sample. Bulk samples may include ash, insulation, or settled dust.
[b] Flowrates are expressed in liters per minute (Lpm); NA = not applicable.
[c] LOD = limit of detection; LOQ = limit of quantitation (values in parentheses).

Table II

Health Effects Summary

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

Substance	Primary Health Effects
Asbestos	Asbestos is a generic term which includes a group of hydrated mineral silicates.[3] Excessive inhalation of asbestos fibers can cause chronic inflammation of lung tissue and pleural membranes as well as cancers (lung, bronchogenic, mesothelioma, stomach, colon, and rectum). There is a fairly long latency period for most of these cancers, often 15 years or more.[4] Cigarette smoking has been implicated as a cocarcinogen among asbestos workers, with cigarette-smoking asbestos workers having 15 times the risk of developing lung cancer as compared with non-smoking asbestos workers.[5]
Crystalline Silica (quartz and cristobalite)	Crystalline silica or free silica causes silicosis, a disabling, progressive and sometimes fatal pulmonary fibrosis. This disease generally occurs following years of exposure and is characterized by nodulation in the lungs.[6] Symptoms include cough, wheezing, shortness of breath, and non-specific chest illness.[3] Impairment of pulmonary function is generally progressive, with the progression of symptoms often continuing after dust exposure has ceased.
Total and Respirable Particulates	Particulate samples were obtained during this survey to assess overall particulate burden. Although TLVs and PELs have been established for nuisance dusts (particulates not otherwise regulated/classified), these criteria do not apply when specific toxic elements are present, such as fly ash particles, which contain several trace metals (see below).
Aluminum	Metallic aluminum dust is considered a relatively benign "inert dust".[3]
Cadmium	NIOSH recommends that exposure to cadmium and its compounds be reduced to the lowest feasible level, as it is considered a potential carcinogen. NIOSH based this recommendation on epidemiologic evidence of a significant excess of cancer deaths among a group of cadmium production workers.[7] Chronic exposure has also been associated with gastrointestinal symptoms, emphysema, kidney disease, and rhinitis.[3]

-Continued-

Table II (Continued)

Health Effects Summary

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

Substance	Primary Health Effects
Chromium	Chromium (Cr) exists in a variety of chemical forms and toxicity varies among the different forms. For example, elemental chromium is relatively non-toxic.[3] Other chromium compounds may cause skin irritation, sensitization, and allergic dermatitis. In the hexavalent form (Cr(VI)), Cr compounds are corrosive, and possibly carcinogenic. Until recently, the less water-soluble Cr(VI) forms were considered carcinogenic while the water-soluble forms were not considered carcinogenic. Recent epidemiological evidence indicates carcinogenicity among workers exposed to soluble Cr(VI) cmpds.[8-12] Based on this new evidence, NIOSH recommends that all Cr(VI) compounds be considered as potential carcinogens.
Copper	Copper fumes and dust can cause irritation of the upper respiratory tract, metallic taste in the mouth, nausea, and congestion of nasal mucous membranes.[14]
Iron	Inhalation of iron oxide dust may cause a benign pneumoconiosis called siderosis.[13]
Nickel	Metallic nickel compounds cause sensitization dermatitis.[3] NIOSH considers nickel a potential carcinogen, as nickel refining has been associated with an increased risk of nasal and lung cancer.[14]
Lead	Chronic lead exposure has resulted in nephropathy (kidney damage), gastrointestinal disturbances, anemia, and neurologic effects.[3] These effects may be felt as weakness, fatigue, irritability, high blood pressure, mental deficiency or slowed reaction times. Lead absorption is cumulative and its elimination from the body is slow. Inhalation of lead dust and fume is the major route of lead absorption in industry, however, signinficant amounts of lead can be ingested from contaminated food, cigarettes or other objects. Chronic lead exposure also has been associated with infertilty and fetal damage in exposed pregnant women.
Carbon Monoxide	Carbon monoxide is a product of incomplete combustion. Overexposure can result in headaches, nausea, dizziness, weakness, and cyanosis. Carbon monoxide combines with oxygen carrying sites on hemoglobin, preventing the blood from carrying sufficient oxygen.[3]
Nitrogen Oxides	Nitrogen oxides may also be products of incomplete combustion. Overexposure can result in irritation of the eyes, nose and throat, cough, dizziness, and chest pain.[14]

Table III

Metal and Mineral Content of Bulk Ash Samples

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

July and October, 1989

Element	Concentration Range (ug/gm)[a] Fly Ash (n = 4)	Combined Ash (n = 3)
Aluminum*	59,000 - 120,000	24,000 - 64,000
Arsenic	b	b
Barium	82 - 190	220 - 700
Beryllium	ND (<1)	ND (<1)
Calcium*	90,000 - 110,000	54,000 - 79,000
Cadmium	78 - 200	3 - 52
Cobalt	16 - 69	7 - 37
Chromium	160 - 390	52 - 300
Copper	570 - 700	200 - 2,000
Iron*	11,000 - 21,000	35,000 - 88,000
Lithium	35 - 50	6 - 30
Magnesium*	12,000 - 26,000	8,400 - 23,000
Manganese	1,200 - 1,700	710 - 1,500
Molybdenum	<2 - 71	7 - 58
Nickel	68 - 180	53 - 200
Lead	1,300 - 1,700	290 - 1,700
Phosphorus	2,400 - 6,200	1,600 - 5,400
Platinum	ND (<20)	ND (<20)
Selenium	ND (<10)	ND (<10)
Silver	11 - 28	<2 - 16
Sodium*	17,000 - 33,000	3,100 - 25,000
Tellurium	ND (<20)	ND (<20)
Thallium	ND (<20)	ND (<20)
Tin	<20 - 1,600	<20 - 510
Titanium*	480 - 23,000	710 - 12,000
Tungsten	ND (<10)	ND (<10)
Vanadium	52 - 120	27 - 85
Yttrium	7 - 13	2 - 10
Zinc*	8,600 - 20,000	1,100 - 14,000
Zirconium	<10 - 150	<10 - 180

[a] Elemental composition is expressed in micrograms per gram of sample (ug/gm).
[b] The presence of arsenic could not be determined due to interferences from aluminum, calcium, iron, and magnesium.
* Indicates elements which were present in concentrations > 1% by weight.

Table IV

Asbestos Content of Insulation and Settled Dust Samples

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

Sample Identification	Asbestos Concentration (%/vol)[a] Chrysotile	Amosite
7-12-89		
Settled dust from 2nd maintenance level - outboard side of #1 long screw	5 - 10	ND[b]
Insulation around steam drum, 5th floor, unit #1	ND	ND
Pipe insulation, main steam line for sootlowers	ND	ND
Insulation for main feed water line, unit #2	30 - 40	ND
Pipe insulation for main steam on roof (outer covering)	ND	80 - 90
Boiler insulation Unit #2 inboard side	ND	ND
Roof to Unit #2 Boiler	<1	ND
10-25-89		
On railing by Unit #1 discharge stairs	ND	ND
Settled dust by unit #1 long screw, maintenance level	ND	ND
Pipe insulation on beam by unit #1 long screw	30 - 40	ND
Bulk pieces of insulation on floor by door to stack, 3rd control room level	ND	70 - 80

[a] Asbestos concentration is reported in percent by volume. Crocidolite, actinolite, and anthophyllite were not detected in any of the samples.
[b] ND = not detected.

Table V

Total Particulate, Respirable Particulate, and Trace Metal Exposures

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

October 25-26, 1989

Job Description	Date	Sampling Time (min)	Sample Volume (liters)	TWA CONTAMINANT CONCENTRATION (mg/m³)[a] Total Dust	Resp Dust	Al	Cd	Cr	Cu	Fe	Ni	Pb
Boiler Fireman	10/25	710	1304			0.12	ND[b]	ND	<0.01	0.04	ND	<0.01
	10/26	493	838	1.9	---							
	10/26	685	896			1.72	<0.01	<0.01	0.02	0.36	ND	0.09
Laborer	10/25	688	1240			0.19	ND	ND	ND	0.06	ND	0.01
	10/25	687	1168	---	0.4							
	10/26	673	885	5.1	---							
	10/26	673	885			0.55	ND	<0.01	0.02	0.13	ND	0.02
Laborer	10/25	464	928			0.39	ND	<0.01	0.01	0.10	ND	0.01
	10/25	464	789	---	0.7							
	10/26	442	663			2.08	<0.01	0.01	0.02	0.41	ND	0.09
	10/26	442	663	11.5	---							
Laborer	10/25	462	924	5.3	---							
	10/25	462	924			0.30	ND	<0.01	<0.01	0.08	ND	0.01
	10/26	670	882			2.64	<0.01	0.01	0.02	0.56	0.003	0.14
Laborer	10/25	684	1163	---	0.5							
	10/25	685	1241			0.21	ND	ND	<0.01	0.05	ND	<0.01
	10/25	124	186			0.81	ND	ND	0.01	0.22	ND	0.03
Truck Driver	10/25	669	1223			0.02	ND	ND	ND	0.01	ND	ND
Maint Mechanic	10/26	446	669			0.15	ND	ND	<0.01	0.08	ND	0.01

-Continued-

Table V (Continued)

Total Particulate, Respirable Particulate, and Trace Metal Exposures

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
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October 25-26, 1989

Job Description	Date	Sampling Time (min)	Sample Volume (liters)	Total Dust	Resp Dust	TWA CONTAMINANT CONCENTRATION (mg/m^3)[a] Al	Cd	Cr	Cu	Fe	Ni	Pb
Maint Mechanic	10/25	445	890			0.11	<0.01	ND	<0.01	0.49	ND	0.02
Utility	10/25	665	1330	1.2	---							
Custodian	10/26	385	578	1.4	---							
Welder	10/25	701	1262			0.06	ND	<0.01	<0.01	0.47	0.002	<0.01
	10/25	671	1192	---	0.3							
Cntrl Rm Oper	10/26	445	668			0.13	ND	ND	<0.01	0.05	ND	0.01
NIOSH Recommended Exposure Limit (REL)				NA[c]	NA	NA	LFL[d]	NA	NA	NA	0.015	<0.10
OSHA Permissible Exposure Limit (PEL)[e]				NA	NA	15	0.2[f]	1	1	10[g]	1	0.05[h]

[a] Concentration of contaminants is expressed as a time-weighted average over the entire sampling period in milligrams per cubic meter (mg/m^3). Al=aluminum; Cd=cadmium; Cr=chromium; Cu=copper; Fe=iron; Ni=nickel; Pb=lead.
[b] ND = none detected.
[c] NA = not applicable.
[d] LFL = lowest feasible level.
[e] The corresponding 8-hour TWAs for the particular elements listed above are the same for both transitional and final rule limits, where applicable.
[f] OSHA is in the process of 6(b) rulemaking on cadmium.
[g] PEL listed for iron is for iron oxide (Fe_2O_3) dust.
[h] The OSHA PEL for lead is 0.05 mg/m^3 as an 8-hour TWA, with an action level of 0.03 mg/m^3. For workshifts of 12-hours, the adjusted PEL for lead is 0.03 mg/m^3.

Table VI

Elemental Analysis of Surface Wipe Samples

Harrisburg Steam Generation Facility
Harrisburg, Pennsylvania
HETA 89-270

October 25-26, 1989

Sample Location	Surface Area Wiped (ft^2)	Elemental Concentration (ug/ft^2)[a] Al	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Ti	Zn
Bench in Break & Locker Rm.	3.0	560	1	3	200	559	9	2	23	67	84
Table in Boiler Control Rm.	4.9	325	2	2	23	509	5	4	21	34	70
Table in Break & Locker Rm. (closest to plant door)	4.0	285	<1	1	160	225	4	1	11	32	41
Turbin Control Rm. Desk	4.0	180	1	1	84	377	4	1	12	19	36
Table in Break & Locker Rm. (furthest from plant door)	4.0	72	<1	<1	12	78	1	2	3	10	26
Front Face of Microwave Oven	1.2	48	<1	<1	12	41	1	1	4	6	10

[a] The elemental concentration is expressed in micrograms of the element per square foot of surface area (ug/ft^2) that was wiped with a Wash N'Dri brand towelette. Al=Alumnium; Cd=cadmium; Cr=chromium; Cu=copper; Fe=iron; Mn=manganese; Ni=nickel; Pb=lead; Ti=titanium; Zn=zinc.

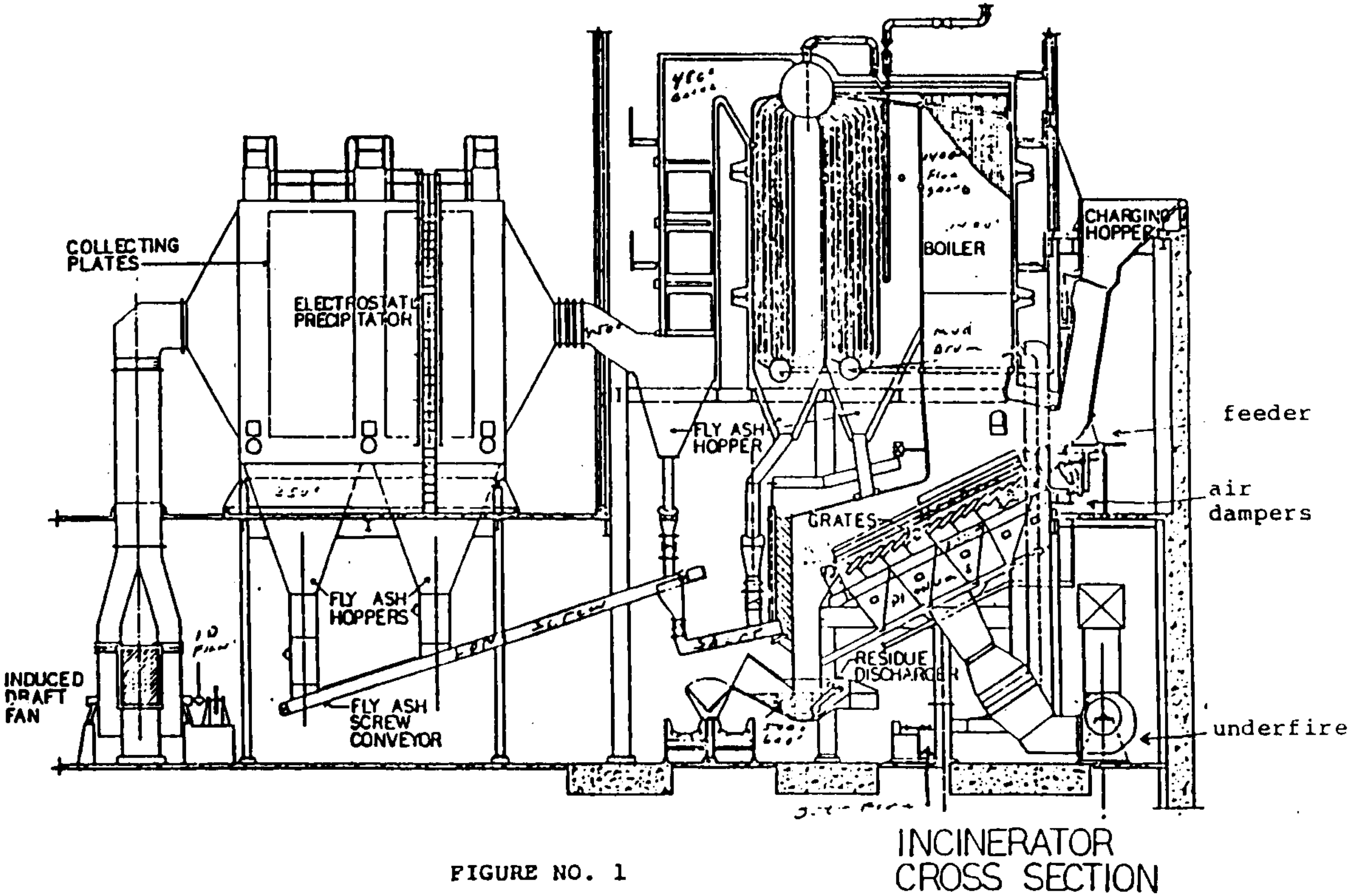

FIGURE NO. 1

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